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The Quantification of Consistent Subjective Logic Tree Branch Weights for PSHA

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The development of quantitative models for the rate of exceedance of seismically generated ground motion parameters is the target of probabilistic seismic hazard analysis (PSHA). In regions of low to moderate seismicity, the selection and evaluation of source- and/or ground-motion models is often a major challenge to hazard analysts and affected by large epistemic uncertainties. In PSHA this type of uncertainties is commonly treated within a logic tree framework in which the branch weights express the degree-of-belief values of an expert in the corresponding set of models. For the calculation of the distribution of hazard curves, these branch weights are subsequently used as subjective probabilities. However the quality of the results depends strongly on the „quality“ of the expert knowledge. A major challenge for experts in this context is to provide weight estimates which are logically consistent (in the sense of Kolmogorov's axioms) and to be aware of and to deal with the multitude of heuristics and biases which affect human judgment under uncertainty. For example, people tend to give smaller weights to each branch of a logic tree the more branches it has, starting with equal weights for all branches and then adjusting this uniform distribution based on his/her beliefs about how the branches differ. This effect is known as pruning bias.[1] A similar unwanted effect, which may even wrongly suggest robustness of the corresponding hazard estimates, will appear in cases where all models are first judged according to some numerical quality measure approach and the resulting weights are subsequently normalized to sum up to one.[2]

To address these problems, we have developed interactive graphical tools for the determination of logic tree branch weights in form of logically consistent subjective probabilities, based on the concepts suggested in Curtis and Wood (2004).[3] Instead of determining the set of weights for all the models in a single step, the computer driven elicitation process is performed as a sequence of evaluations of relative weights for small subsets of models which are presented to the analyst. From these, the distribution of logic tree weights for the whole model set is determined as solution of an optimization problem. The model subset presented to the analyst in each step is designed to maximize the expected information. The result of this process is a set of logically consistent weights together with a measure of confidence determined from the amount of conflicting information which is provided by the expert during the relative weighting process.

[1] Fox, C. R., and R. T. Clemen (2005). Subjective Probability Assessment in Decision Analysis: Partition Dependence and Bias Toward the Ignorance Prior. Management Science 51, no. 9: 1417-1432.
[2] Scherbaum, F. , and N. M. Kuehn (2011). Logic Tree Branch Weights and Probabilities: Summing Up to One Is Not Enough. Earthquake Spectra 27, no. 4: 1237.
[3] Curtis, A. , and R. Wood (2004). Optimal Elicitation of Probabilistic Information From Experts. Geological Society, London, Special Publications 239, no. 1: 127.